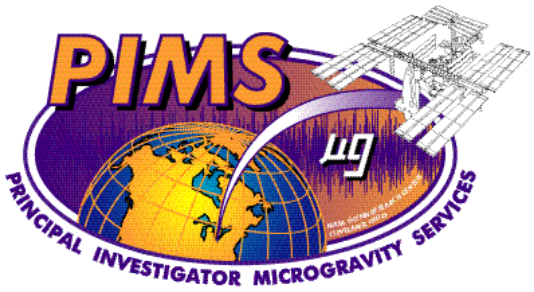
Principal Investigator Microgravity Services



Software Requirements for Processing Microgravity Acceleration Data from the International Space Station

PIMS-ISS-001

May 2000
Rev - Baseline

NASA Glenn Research Center
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Revision History

Revision	Effective Date	Description
Baseline	May 19, 2000	Baseline Release

Acronyms and Abbreviations

AOS	Acquisition of Signal
CCSDS	Consultative Committee for Space Data Systems
EHS	Enhanced HOSC System
GRC	Glenn Research Center
GSE	Ground Support Equipment
HiRAP	High Resolution Accelerometer Package
HOSC	Huntsville Operations Support Center
ISS	International Space Station
LOS	Loss of Signal
MAMS	Microgravity Acceleration Measurement System
MMAP	Microgravity Measurement and Analysis Project
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
OARE	Orbital Acceleration Research Experiment
OLMSA	Office of Life and Microgravity Sciences and Applications
OSS	OARE Sensor Subsystem
PAD	PIMS Acceleration Data
PCSA	Principal Component Spectral Analysis
PDSS	Payload Data Services System
PI	Principal Investigator
PIMS	Principal Investigator Microgravity Services
QTH	Quasi-steady Three-Dimensional Histogram
RMS	Root-Mean-Square
RSS	Root-Sum-Square
RTS	Remote Triaxial Sensor System
SAMS-II	Space Acceleration Measurement System-II
SE	Sensor Enclosure
TMF	Trimmean Filter
TSC	Telescience Support Center
WWW	World Wide Web

Table of Contents

1. Introduction

The NASA Glenn Research Center (GRC) Principal Investigator Microgravity Services (PIMS) project supports NASA's Microgravity Research Division Principal Investigators (PIs) by providing acceleration data analysis and interpretation for a variety of microgravity carriers including the International Space Station (ISS), the Space Shuttle, the Russian Mir Space Station, parabolic aircraft, sounding rockets, and drop towers. The PIMS project is funded by the NASA Headquarters Office of Life and Microgravity Sciences and Applications (OLMSA) and is part of the NASA Glenn Research Center's Microgravity Measurement and Analysis Project (MMAP), which integrates the analysis and interpretation component of PIMS with the various NASA sponsored acceleration measurement systems. For the ISS, these acceleration measurement systems include the Space Acceleration Measurement System-II (SAMS-II) and the Microgravity Acceleration Measurement System (MAMS).

The requirements specified in this document are derived primarily from expertise obtained by the PIMS project during operational support of Space Shuttle microgravity missions and from PI requirements captured in the Experiment Support Requirements Document [1] and the International Space Station Program Microgravity Control Plan [2]. The compilation of the requirements from these sources represents a set of requirements that have been identified primarily from Space Shuttle microgravity missions. In general, the PIMS project's acceleration data support efforts are to archive and disseminate accelerometer data; to support users interested in the microgravity acceleration environment by providing information about activities and acceleration sources; to identify acceleration sources related to vehicle systems, experiment hardware, vibration isolation systems, and other systems; to design data analysis techniques and displays per user requirements; to educate users about the environment and data analysis techniques; to provide standard data interpretation reports; and to characterize the microgravity environment of the ISS in support of PIs.

2. Background and Scope

This document defines the requirements for PIMS ground processing software. Consequently, the requirements must be separated into their logical components based on the broad scope of the PIMS project's responsibilities regarding the management of acceleration data during ISS operations. These logical components have been identified as real time system requirements, near real time requirements, offline system requirements, storage requirements, and general support requirements.

To address any new requirements that originate based on ISS operations, this document will contain sections called *Generic Requirements* and *Increment Specific Requirements*. The generic requirements are intended to reflect capabilities that may serve multiple PIs, such as displaying the acceleration data in a specific manner. Increment specific requirements are intended to capture PI requirements that are not adequately addressed by the current set of generic requirements. Both the *Generic Requirements* and the *Increment Specific Requirements* sections of this document will have subsections based on the logical components identified in the top-level paragraph. If deemed appropriate, an increment specific requirement will be added to the generic requirements of this document and be available for operations during subsequent increments.

The increment specific paragraphs that follow consist of two basic parts. The first part summarizes the basic operating concept for each increment. This basic operating concept is intended to describe the basic flow of data from on board the ISS to the PIMS Ground Support Equipment (GSE) and ultimately to PIs. This includes any changes and improved capabilities of the overall acceleration data system that is comprised of the Marshall Space Flight Center (MSFC) Enhanced Huntsville Support Center (HOSC) System (EHS), the Glenn Research Center (GRC) Telescience Support Center (TSC), and the PIMS ISS software. The second part of the increment specific paragraphs serves to summarize any increment specific changes to the PIMS ISS software. As described previously, such a change would be the result of an increment specific requirement being added to the PIMS ISS software for use in subsequent increments.

2.1. Increment 2 Operations

The basic data flow for initial operations involves the transmission and acquisition of SAMS-II and MAMS data in real time. The PIMS GSE will be located at the GRC TSC where acceleration data packets from both accelerometer systems will be received and written to a database in real time. In real time, the display generation software will extract data from the database, decommutate the data, and display the data on PIMS GSE. Periodic electronic snapshots of these plotted images will be obtained and made available to the science community via the PIMS ISS World Wide Web (WWW) page.

The database that is used as a source of data for generating real time displays will similarly receive data from prior Loss of Signal (LOS) periods. The action of writing the LOS data to the database performs a merge of Acquisition of Signal (AOS) and LOS data, resulting in a complete set of data packets for each supported accelerometer system.

In parallel to the real time display of the acceleration data, PIMS GSE will archive the acceleration data in two formats, raw data packets and processed acceleration data. The software responsible for archiving raw data packets or processed acceleration data uses the database

described above as its initial source of data for processing. The raw data packets serve as an unprocessed archive of the data packets as received by the PIMS GSE. The processed acceleration data will also serve as an archive, but the data will be stored in engineering units instead of unprocessed, raw data. This processed acceleration data will be available to PIMS data analysts and PIs for subsequent offline analysis and offline experiment to acceleration environment data correlation.

3. Document Specific Definitions

Data

As used in this document, the term data alone generically refers to all data types available for processing. Any requirement specific to the processing or manipulation of a particular accelerometer system's data will have the term data preceded by the appropriate descriptor, such as SAMS-II data.

Rates and Angles Data

Refers to the data set composed of the Space Station body angles, body rates, and other parameters required to map the MAMS Orbital Acceleration Research Experiment (OARE) Sensor Subsystem (OSS) data to alternate locations within the Space Station

Real Time Data

Data transmitted from the HOSC containing an indication that the data were received from an ISS AOS period

Near Real Time Data

Data transmitted from the HOSC containing an indication that the data were received from an ISS LOS period

WWW Update Rate

Interval of time between snapshots of acceleration data images

4. Generic Requirements

4.1. Real-Time Requirements

4.1.1. General

The items described here are top-level functions to be performed by the PIMS real-time software. The PIMS real-time software operates on data during AOS periods. PIMS ISS real-time software will perform the following tasks.

4.1.1.1. Communication
PIMS ISS real-time software will initiate, terminate, and re-establish communications with the EHS as required to maintain data flow.

4.1.1.2. SAMS-II Data Acquisition
PIMS ISS real-time software will process, store, and distribute acceleration data from up to 10 SAMS-II Remote Triaxial Sensors Systems (RTS).

4.1.1.3. SAMS-II Configuration
PIMS ISS real-time software will recognize changes in the SAMS-II configuration, including changes in the number of sensor heads, the location/position of the sensor heads, and the sample rate associated with a particular sensor head.

4.1.1.4. MAMS Data Acquisition
PIMS ISS real-time software will process, store, and distribute acceleration data from the MAMS.

4.1.1.5. MAMS Configuration
PIMS ISS real-time software will recognize changes in the MAMS configuration, including changes in the location of the sensor.

4.1.1.6. Rates and Angles GSE Data Packet Acquisition
PIMS ISS real-time software will process and store GSE packets as required to allow mapping of quasi-steady accelerations to any point within the ISS.

4.1.2. Data Inputs
The items listed are data types that will be presented to the PIMS real-time software system.

4.1.2.1. SAMS-II Data
PIMS ISS software will receive SAMS-II Payload Data Services System (PDSS) payload Consultative Committee for Space Data Systems (CCSDS) packets.

4.1.2.2. MAMS Data
PIMS ISS software will receive MAMS PDSS payload CCSDS packets.

4.1.2.3. Rates and Angles Data
PIMS ISS software will receive ISS rates and angles data in the form of EHS GSE packets.

4.1.3. PIMS Operator Inputs
The items listed are inputs that the PIMS operators will be able to select to control limited aspects of the PIMS real-time software system. A requirement that does not reference a particular data type is considered a generic input requirement. The generic input requirements are listed first.

4.1.3.1. Accelerometer System
The PIMS ISS real time software will allow selection of data from the appropriate accelerometer system.

4.1.3.2. WWW Update Rate

PIMS ISS software will allow selection of the time interval between snapshots of plotted real time data that is to be displayed on the PIMS WWW ISS page.

4.1.3.3. Output Format for Data

PIMS ISS software will allow selection of the output format for the processed data, including generation of plotted image data or storage to file.

4.1.3.4. Coordinate System Selection

PIMS ISS software will allow selection of the coordinate system for the data display or data file, including sensor head coordinates and various ISS coordinate systems.

4.1.3.5. Display and Processing Selection

PIMS ISS software will allow selection of the type of processing for the selected data and selection of the display parameters available for a given display option. Section 4.1.4 includes details regarding the options available for each data type.

4.1.3.6. Sensor Enclosure (SE) Selection (SAMS-II Only)

PIMS ISS software will allow selection of a triaxial sensor head or triaxial sensor heads for processing.

4.1.3.7. Mapping to Alternate Locations (MAMS OSS Only)

PIMS ISS software will allow selection of alternate ISS locations for mapping MAMS OSS data.

4.1.3.8. Frame of Reference Selection (MAMS OSS Only)

PIMS ISS software will allow selection of the frame of reference, including an ISS or inertial reference frame.

4.1.3.9. Filtering Type Selection (MAMS OSS Only)

PIMS ISS software will allow selection of the filtering for the MAMS OSS raw data, including trimmean filter (TMF) and interval average.

4.1.4. Processing

This section identifies some low-level processing requirements of the PIMS ISS software. Further, this section identifies the software functions available for execution on the various data types based on user inputs. The function lists below provide a complete list of available options for a given data type. They do not necessarily represent all the functions that will be concurrently executed for a selected data type. For example, even though ten options may be available, all ten options may not be simultaneously executed.

Table 1 lists options available to PIMS operators for control of time domain plot options. Table 2 lists options available to PIMS operators for control of frequency domain plot options. Each plot type is listed with appropriate available options indicated with an ‘X’. A brief description of each plot type and its suggested utilization is provided in table 3. A more detailed description of these

analysis techniques is available in the Accelerometer Data Analysis and Presentation Techniques document [3].

4.1.4.1. Low-level Processing Requirements

4.1.4.1.1. EHS Communication

PIMS ISS software will maintain communications with the EHS for transfer and processing of data packets.

4.1.4.1.2. Database Insertion

PIMS ISS software will insert all received real time data packets for all available data inputs into the PIMS database.

4.1.4.1.3. SAMS-II Data Decommutation

PIMS ISS software will separate the SAMS-II data stream into data based on SE.

4.1.4.1.4. MAMS OSS Data Decommutation

PIMS ISS software will separate the MAMS OSS data frame into acceleration data and MAMS ancillary data.

4.1.4.1.5. MAMS HiRAP Data Decommutation

PIMS ISS software will decommutate the MAMS High Resolution Accelerometer Package (HiRAP) data frame into acceleration data.

4.1.4.1.6. Rates and Angles Data Decommutation

PIMS ISS software will decommutate the rates and angles GSE data frame into ISS ancillary data (ISS body rates data, ISS body angles data, and ISS center of gravity data) required to support mapping of MAMS OSS data to alternate ISS experiment locations.

4.1.4.1.7. Coordinate System Transformation

PIMS ISS software will be capable of transforming the SAMS-II data or the MAMS data from its sensor coordinate system to another coordinate system.

4.1.4.1.8. Mapping to Alternate ISS Locations

PIMS ISS software will be capable of mapping the MAMS OSS data from the MAMS location to alternate ISS experiment locations.

4.1.4.2. Processing Requirements for SAMS-II Data and MAMS HiRAP Data

4.1.4.2.1. Acceleration Versus Time

The PIMS ISS software shall be capable of generating RSS or XYZ orthogonal axes acceleration versus time.

4.1.4.2.2. Interval Minimum/Maximum Acceleration Versus Time

The PIMS ISS software shall be capable of generating RSS or XYZ orthogonal axes interval minimum/maximum acceleration versus time.

4.1.4.2.3. Interval Average Acceleration Versus Time

The PIMS ISS software shall be capable of generating RSS or XYZ orthogonal axes interval average acceleration versus time.

4.1.4.2.4. Interval RMS Acceleration Versus Time

The PIMS ISS software shall be capable of generating RSS or XYZ orthogonal axes interval gRMS acceleration versus time.

4.1.4.2.5. Power Spectral Density Versus Frequency

The PIMS ISS software shall be capable of generating sum or XYZ orthogonal axes power spectral density versus frequency.

4.1.4.2.6. Color Spectrogram

The PIMS ISS software shall be capable of generating sum or XYZ orthogonal axes color spectrogram.

4.1.4.2.7. Cumulative RMS Versus Frequency

The PIMS ISS software shall be capable of generating RSS or XYZ orthogonal axes cumulative RMS acceleration versus frequency.

4.1.4.2.8. RMS Acceleration Versus Time – Selectable Frequency Band

The PIMS ISS software shall be capable of generating RSS or XYZ orthogonal axes RMS acceleration versus time for user selected frequency band.

4.1.4.2.9. One-third Octave Band RMS Acceleration Versus Frequency

The PIMS ISS software shall be capable of generating RMS acceleration versus time for the ISS one-third octave bands. An optional overlay of the ISS requirements curve can be selected.

4.1.4.3. Processing Requirements for MAMS OSS Data

4.1.4.3.1. Acceleration Versus Time

The PIMS ISS software shall be capable of generating XYZ orthogonal axes acceleration versus time.

4.1.4.3.2. Interval Minimum/Maximum Acceleration Versus Time

The PIMS ISS software shall be capable of generating XYZ orthogonal axes interval minimum/maximum acceleration versus time.

4.1.4.3.3. Interval Average Acceleration Versus Time

The PIMS ISS software shall be capable of generating XYZ orthogonal axes interval average acceleration versus time.

4.1.4.3.4. TMF Acceleration Versus Time

The PIMS ISS software shall be capable of generating XYZ orthogonal axes TMF acceleration versus time.

4.1.4.3.5. MAMS OSS Bias Data Versus Time

The PIMS ISS software shall be capable of generating XYZ orthogonal axes OSS bias acceleration versus time.

4.1.4.4. Processing Requirements for Rates and Angles GSE Packet Data

4.1.4.4.1. Body Rates Versus Time

The PIMS ISS software shall be capable of generating 3 axes (pitch, yaw, roll) ISS body rates versus time.

4.1.4.4.2. Body Angles Versus Time

The PIMS ISS software shall be capable of generating 3 axes (pitch, yaw, roll) ISS body angles versus time.

4.1.4.4.3. ISS Ancillary Data Versus Time

The PIMS ISS software shall be capable of generating Other ISS ancillary data versus time.

4.1.5. Outputs

This section identifies the products available as outputs from the PIMS ISS real-time software. They are determined by the input options selected at the PIMS facility at the TSC. All relevant parameters including selected input options will be displayed with the plotted data.

4.1.5.1. PIMS Software Executed at the PIMS facility

4.1.5.1.1. Request for Plotted Data

The PIMS ISS software will distribute processed images of acceleration data via the WWW.

4.1.5.1.2. Requests for Stored Data

The PIMS ISS software will process and store acceleration data to data files. The resultant files will be accessible via a PIMS provided file server.

4.1.5.1.3. Hard Copy Availability

The PIMS ISS software will provide the capability to send displayed images to a local printer or to a stored image file.

4.1.5.2. Additional Outputs

4.1.5.2.1. Expert System Display

The PIMS ISS software will generate an expert system page summarizing vibratory and high frequency realm disturbance sources.

4.1.5.2.2. Quasi-Steady Acceleration Summary Display

The PIMS ISS software will generate a quasi-steady environment summary page, including ISS body rates and body angles.

4.1.5.2.3. MAMS OSS Housekeeping Data Display

The PIMS ISS software will generate a MAMS OSS housekeeping data summary page.

4.1.5.2.4. Packets Stored in PIMS Database

The PIMS ISS software will store received real time data packets in the PIMS database for subsequent access by display processing programs, PIMS Acceleration Data (PAD) file processing programs, and raw data archival programs.

Table 1 – Acceleration Versus Time Plot Control Options

Section	Plot Description	Time Span (min,max,tick)	Amplitude (min,max,tick)	TMF Parameters	Mapping Location	Interval
4.1.4.2.1	Acceleration vs. Time	X	X			
4.1.4.2.2	Interval Min/Max Acceleration vs. Time	X	X			X
4.1.4.2.3	Interval Average Acceleration vs. Time	X	X			X
4.1.4.2.4	Interval RMS Acceleration vs. Time	X	X			X
4.1.4.3.1	Acceleration vs. Time	X	X		X	
4.1.4.3.2	Interval Min/Max Acceleration vs. Time	X	X		X	X
4.1.4.3.3	Interval Average Acceleration vs. Time	X	X		X	X
4.1.4.3.4	TMF Acceleration vs. Time	X	X	X	X	
4.1.4.3.5	MAMS OSS Bias Data vs. Time	X	X			

Table 2 - Frequency Domain Plot Control Options

Section	Plot Description	X-Axis and Y-Axis Limits	Frequency Resolution Δf	Colorbar Limits	Windowing Selection	Frequency Bands	Mode Selection	Temporal Resolution dT
4.1.4.2.5	PSD vs. Frequency	X	X		X			
4.1.4.2.6	Color Spectrogram	X	X	X	X			X
4.1.4.2.7	Cumulative RMS vs. Frequency	X	X		X			
4.1.4.2.8	RMS Acceleration for Selected Frequency Bands	X	X		X	X		X
4.1.4.2.9	One-Third Octave Band		X		X		X†	

† - Use an interval of T=100 seconds or select a power of 2 number of points such that $T \geq 100$ seconds

Table 3 - Acceleration Data Display Descriptions

Section	Display Format	Regime(s)	Notes
4.1.4.2.1	Acceleration versus Time	Transient, Quasi-Steady, Vibratory	• precise accounting of measured data with respect to time; best temporal resolution
4.1.4.2.2	Interval Min/Max Acceleration versus Time	Vibratory, Quasi-Steady	• displays upper and lower bounds of peak-to-peak excursions of measured data • good display approximation for time histories on output devices with resolution insufficient to display all data in time frame of interest
4.1.4.2.3	Interval Average Acceleration versus Time	Vibratory, Quasi-Steady	• provides a measure of net acceleration of duration greater than or equal to interval parameter
4.1.4.2.4	Interval RMS Acceleration versus Time	Vibratory	• provides a measure of peak amplitude
4.1.4.3.4	Trimmed Mean Filtered Acceleration versus Time	Quasi-Steady	• removes infrequent, large amplitude outlier data
4.1.4.1.8	Quasi-Steady Mapped Acceleration versus Time	Quasi-Steady	• use rigid body assumption and vehicle rates and angles to compute acceleration at any point in the vehicle
4.3.4.3.5	Quasi-Steady Three-Dimensional Histogram (QTH)	Quasi-Steady	• summarize acceleration magnitude and direction for a long period of time • indication of acceleration "center-of-time" via projections onto three orthogonal planes
4.1.4.2.5	Power Spectral Density (PSD) versus Frequency	Vibratory	• displays distribution of power with respect to frequency
4.1.4.2.6	Spectrogram (PSD versus Frequency versus Time)	Vibratory	• displays power spectral density variations with time • identify structure and boundaries in time and frequency
4.1.4.2.7	Cumulative RMS Acceleration versus Frequency	Vibratory	• quantifies RMS contribution at and below a given frequency
4.1.4.2.8	Frequency Band(s) RMS Acceleration versus Time	Vibratory	• quantify RMS contribution over selected frequency band(s) as a function of time
4.1.4.2.9	RMS Acceleration versus One-Third Frequency Bands	Vibratory	• quantify RMS contribution over proportional frequency bands • compare measured data to ISS vibratory requirements
4.3.4.2.10	Principal Component Spectral Analysis (PCSA)	Vibratory	• summarize magnitude and frequency excursions for key spectral contributors over a long period of time • results typically have finer frequency resolution and high PSD magnitude resolution relative to a spectrogram at the expense of poor temporal resolution

4.2. Near Real-Time Requirements

4.2.1. General

The items listed are top-level functions to be performed by the PIMS near real-time software. The PIMS near real-time software receives data from LOS periods for the various data types identified. PIMS ISS near real-time software will perform the following tasks for the playback of data recorded on board the ISS during LOS periods.

4.2.1.1. Near Real-Time Communication

PIMS near real-time software will maintain data flow with the EHS.

4.2.1.2. Near Real-Time SAMS-II Data Acquisition

PIMS near real-time software will process and store acceleration data from up to 10 SAMS-II RTS.

4.2.1.3. Near Real-Time SAMS-II Configuration

PIMS near real-time software will recognize changes in SAMS-II environment, including changes in the number of sensor heads, the location/position of the sensor heads, and the sample rate associated with a particular sensor head.

4.2.1.4. Near Real-Time MAMS Data Acquisition

PIMS near real-time software will process and store acceleration data from the MAMS.

4.2.1.5. Near Real-Time MAMS Configuration

PIMS near real-time software will recognize changes in the MAMS environment, including changes in the location of the sensor.

4.2.1.6. Near Real-Time Rates and Angles GSE Data Packet Acquisition

PIMS near real-time software will process and store GSE data packets as required to allow mapping of quasi-steady accelerations to any point within the ISS.

4.2.2. Data Inputs

The items listed are data types that will be presented to the PIMS near real-time software system. PIMS ISS near real-time software will accept the following data inputs for the playback of data recorded on board the ISS during LOS periods.

4.2.2.1. Near Real-Time SAMS-II Data

PIMS near real-time software will receive SAMS-II PDSS payload CCSDS packets.

4.2.2.2. Near Real-Time MAMS Data

PIMS near real-time software will receive MAMS PDSS payload CCSDS packets.

4.2.2.3. Near Real-Time Rates and Angles Data

PIMS near real-time software will receive EHS GSE data packets.

4.2.3. User Inputs

The near real-time system operates in the background from the real-time system. Its focus is to receive data from LOS periods for eventual merging with AOS data received by the real-time system. As a result of this focus, there are no user inputs for the near real-time system.

4.2.4. Processing

This section identifies the low level processing requirements of the near real-time software. As mentioned previously, the near real-time system operates in the background from the real-time system. The only processing that occurs is the receipt of LOS data packets and their insertion into the PIMS database.

4.2.4.1. Database Insertion

PIMS ISS software will insert all received near real-time data packets for all available data inputs into the PIMS database.

4.2.5. Outputs

This section identifies the products available for output from the PIMS ISS near real-time software.

4.2.5.1. Packets Stored in PIMS Database

The PIMS ISS software will store received near real-time data packets in the PIMS database for subsequent access by PAD file processing programs and raw data archival programs.

4.3. Offline Requirements

4.3.1. General

The PIMS offline software will provide an interface to acceleration data from accelerometer systems specifically supported by the MMAP. This interface will allow users to plot acceleration data in a variety of formats or to extract acceleration data into data files for manipulation by user-generated software.

4.3.2. Data Inputs

The items listed are data types that will be available for processing by the PIMS offline software system. PIMS ISS software will be capable of processing the following data types.

4.3.2.1. Offline SAMS-II Data

The PIMS ISS offline software will be able to process requests for SAMS-II data.

4.3.2.2. Offline MAMS Data

The PIMS ISS offline software will be able to process requests for MAMS data.

4.3.2.3. Offline Rates and Angles Data

The PIMS ISS offline software will be able to process requests for ISS body rates and ISS body angles data.

4.3.3. User Inputs

The items listed are user inputs for the PIMS ISS offline software system that will control the manipulation of the data requested and control the format for the data requested (plots, data files, etc.). The generic user inputs for the PIMS ISS offline software are listed first and are common parameters available for control of the data input types available.

4.3.3.1. Offline Processor Graphical User Interface

PIMS ISS offline software will include a graphical user interface to facilitate the offline processing of processed data by PIMS personnel and directly by PIs. The following parameters will be included as graphical user interface options.

4.3.3.1.1. Accelerometer System

The PIMS ISS offline software will allow selection of data from the appropriate accelerometer system.

4.3.3.1.2. Output Format for the Data

The PIMS ISS offline software will allow selection of the output format for the processed data, including generation of plotted image data or storage to file.

4.3.3.1.3. Time Interval

The PIMS ISS offline software will allow selection of the time interval of interest for processing.

4.3.3.1.4. Offline Coordinate System Selection

The PIMS ISS offline software will allow selection of the coordinate system for the display of sensor data (SE coordinate system, ISS module coordinate system, etc.).

4.3.3.1.5. Offline Display and Processing Selection

The PIMS ISS offline software will allow selection of the type of processing for the selected data. Section 4.3.4 includes details regarding the available options for each input data type.

4.3.3.1.6. Offline SE Selections (SAMS-II Only)

The PIMS ISS offline software will allow selection of the triaxial sensor head for processing.

4.3.3.1.7. Mapping to Alternate Locations (MAMS OSS Only)

The PIMS ISS offline software will allow selection of alternate locations for mapping MAMS OSS data.

4.3.3.1.8. Offline Frame of Reference Selection (MAMS OSS Only)

The PIMS ISS offline software will allow selection of the frame of reference for the presentation of the data, including ISS and inertial reference frames.

4.3.3.1.9. Offline Filtering Type Selection (MAMS OSS Only)

The PIMS ISS offline software will allow selection of the filtering type for the MAMS OSS data, including TMF and interval average.

4.3.4. Processing

This section identifies some low-level processing requirements of the software. Further, this section identifies the software functions available for execution on the various data inputs based on user inputs. The functions listed below comprise a complete list of available options, which does not necessarily represent all the functions that will be executed for a given set of inputs.

Table 1 lists options available to PIMS operators for control of time domain plot options. Table 2 lists options available to PIMS operators for control of frequency domain plot options. Each plot type is listed with appropriate available options indicated with an 'X'. A detailed description of these analysis techniques is available in the Acceleration Data Analysis and Presentation Techniques document [3].

4.3.4.1. Offline Low-level Processing Requirements

4.3.4.1.1. Offline Coordinate System Transformation

The PIMS ISS offline software will allow transformation of the SAMS-II data or the MAMS data from sensor coordinate system to another ISS coordinate system.

4.3.4.1.2. Offline Mapping to Alternate ISS Locations

The PIMS ISS offline software will allow mapping the MAMS OSS data from the MAMS location to alternate ISS experiment locations.

4.3.4.2. Processing Requirements for SAMS-II Data and MAMS HiRAP Data

4.3.4.2.1. Acceleration Versus Time

The PIMS ISS offline software shall be capable of generating RSS or XYZ orthogonal axes acceleration versus time.

4.3.4.2.2. Interval Minimum/Maximum Acceleration Versus Time

The PIMS ISS offline software shall be capable of generating RSS or XYZ orthogonal axes interval minimum/maximum acceleration versus time.

4.3.4.2.3. Interval Average Acceleration Versus Time

The PIMS ISS offline software shall be capable of generating RSS or XYZ orthogonal axes interval average acceleration versus time.

4.3.4.2.4. Interval RMS Acceleration Versus Time

The PIMS ISS offline software shall be capable of generating RSS or XYZ orthogonal axes interval gRMS acceleration versus time.

4.3.4.2.5. Power Spectral Density Versus Frequency

The PIMS ISS offline software shall be capable of generating sum or XYZ orthogonal axes power spectral density versus frequency.

4.3.4.2.6. Color Spectrogram

The PIMS ISS offline software shall be capable of generating sum or XYZ orthogonal axes color spectrogram.

4.3.4.2.7. Cumulative RMS Versus Frequency

The PIMS ISS offline software shall be capable of generating RSS or XYZ orthogonal axes cumulative RMS acceleration versus frequency.

4.3.4.2.8. RMS Acceleration Versus Time – Selectable Frequency Band

The PIMS ISS offline software shall be capable of generating RSS or XYZ orthogonal axes RMS acceleration versus time for user selected frequency band.

4.3.4.2.9. One-third Octave Band RMS Acceleration Versus Frequency

The PIMS ISS offline software shall be capable of generating RMS acceleration versus time for the one-third octave bands.

4.3.4.2.10. Principal Component Spectral Analysis (PCSA)

The PIMS ISS offline software shall be capable of generating PCSA plots.

4.3.4.3. Processing Requirements for MAMS OSS Data

4.3.4.3.1. Acceleration Versus Time

The PIMS ISS offline software shall be capable of generating XYZ orthogonal axes acceleration versus time.

4.3.4.3.2. Interval Minimum/Maximum Acceleration Versus Time

The PIMS ISS offline software shall be capable of generating XYZ orthogonal axes interval minimum/maximum acceleration versus time.

4.3.4.3.3. Interval Average Acceleration Versus Time

The PIMS ISS offline software shall be capable of generating XYZ orthogonal axes interval average acceleration versus time.

4.3.4.3.4. TMF Acceleration Versus Time

The PIMS ISS offline software shall be capable of generating XYZ orthogonal axes TMF acceleration versus time.

4.3.4.3.5. Quasi-steady Three-Dimensional Histograms (QTH)

The PIMS ISS offline software shall be capable of generating QTH plots.

4.3.4.3.6. Quasi-Steady Compliance Checking

The PIMS ISS offline software shall be capable of performing quasi-steady acceleration environment compliance checking.

4.3.4.4. Processing Requirements for Rates and Angles GSE Packet Data

4.3.4.4.1. Body Rates Versus Time

The PIMS ISS offline software shall be capable of generating 3 axes (pitch, yaw, roll) ISS body rates versus time.

4.3.4.4.2. Body Angles Versus Time

The PIMS ISS offline software shall be capable of generating 3 axes (pitch, yaw, roll) ISS body angles versus time.

4.3.4.4.3. ISS Ancillary Data Versus Time

The PIMS ISS offline software shall be capable of generating Other ISS ancillary data versus time.

4.3.5. Outputs

This section identifies the products available for output from the PIMS ISS offline software. The user selects the format of the output products. They are determined by the user-input selections and the selected processing type.

4.3.5.1. Offline Plotted Data Requests

The PIMS ISS offline software will display processed acceleration data at the PIMS offline-processing terminal or at the PIs local machine.

4.3.5.2. Offline Stored Data Requests

The PIMS ISS offline software will process and store acceleration data to data files.

4.3.5.3. Offline Hard Copy Availability

The PIMS ISS offline software will provide the capability to store processed data to file and to print or store displayed images in a variety of formats, including JPG, PDF, and post-script. The resultant files will be available via a PIMS provided file server.

4.4. Storage Requirements

4.4.1. General

The storage requirements for the PIMS software address the issues of data storage relative to the real-time, near real-time, and offline systems. Each of these systems presents unique requirements for the storage of and access to the data from the various accelerometers supported by the Acceleration Measurement Program.

The PIMS ISS storage system will store data from each accelerometer system supported. Data will be stored in either raw packet format or in processed acceleration data. Raw packets are stored strictly for archival purposes. Processed data are stored for ready access by the PIMS offline processing system discussed in section 4.3 or by PI specific acceleration data processing software. Section 2.1 provides additional detail about these two data formats. Each of these two data types presents unique storage requirements.

Any discussions of storage requirements apply only to PIMS equipment at the GRC TSC. PIMS software executed at a PI's remote location will have data storage specific functions disabled.

4.4.1.1. SAMS-II Configuration (Processed Acceleration Data Only)

PIMS ISS storage software will recognize changes in the SAMS-II configuration, including changes in the number of sensor heads, the location/position of the sensor heads, and the sample rate associated with a particular sensor head

4.4.1.2. Random Access

PIMS ISS storage software will use storage media that allows random access to acceleration data.

4.4.1.3. Merged AOS/LOS Data

PIMS ISS storage software will process and store AOS/LOS merged data.

4.4.1.4. Universal File Format (Processed Acceleration Data Only)

PIMS ISS storage software will store data in a universal file format, including directory hierarchy, filename, and file content.

4.4.1.5. Data Accessibility

PIMS ISS storage software will store data on a universally acceptable/accessible storage media.

4.4.1.6. Descriptive Record (Processed Acceleration Data Only)

PIMS ISS storage software will include with each file a descriptive record that describes the circumstances under which the data were obtained, including sampling rate, location, and orientation of sensor heads.

4.4.2. Data Inputs

The items listed are data types that can be processed by the PIMS ISS storage system.

4.4.2.1. SAMS-II Acceleration Data Storage

PIMS ISS software will be capable of processing SAMS-II data.

4.4.2.2. MAMS OSS Data Storage

PIMS ISS software will be capable of processing MAMS OSS data.

4.4.2.3. MAMS HiRAP Data Storage

PIMS ISS software will be capable of processing MAMS HiRAP data.

4.4.2.4. GSE Packet Data Storage

PIMS ISS software will be capable of processing GSE packet data.

4.4.3. User Inputs

There are no direct user inputs that control the PIMS ISS storage system. The data stored are a function of user inputs made in section 4.1.3. The data are obtained from the PIMS database that contains merged AOS and LOS packets from the various data types available.

4.4.4. Processing

This section identifies some low-level processing requirements of the PIMS ISS storage system.

4.4.4.1. Timestamp Generation

The PIMS ISS storage system will include a timestamp from on-board the ISS for each data record created.

4.4.4.2. SAMS-II Data Decommutation

The PIMS ISS storage system will decommutate the SAMS-II data into XYZ acceleration data.

4.4.4.3. MAMS Data Decommutation

The PIMS ISS storage system will decommutate the MAMS data into XYZ acceleration data.

4.4.4.4. GSE Packet Data Decommutation

The PIMS ISS storage system will decommutate the GSE packet data.

4.4.4.5. Offline Access of Data

The PIMS ISS storage system will move processed data to the offline storage facility for access by the offline processing software.

4.4.5. Outputs

This section identifies the products available for output from the PIMS ISS storage system.

4.4.5.1. Processed Data

The PIMS ISS storage system will provide processed AOS/LOS merged data files in a universal file format accessible for subsequent processing by the PIMS ISS offline processing software.

4.4.5.2. Raw Data Packet

The PIMS ISS storage system will provide merged raw packet data files for storage in the PIMS ISS archives.

4.5. Generic Requirements

The generic requirements covered under this section represent capabilities that will be provided by PIMS for ISS operations.

4.5.1. Electronic Mail Request System

PIMS will provide an email request system as an electronic method to request processed data.

4.5.2. Automatic Updates to PIMS ISS User Request Database

PIMS will automatically update the PIMS user request database based on requests received via the e-mail request system.

4.5.3. Universal Data File Reader

PIMS will provide a universal data file reader for viewing of processed data.

4.5.4. Accelerometer System Interface Definition Documents

PIMS will develop, as required, interface definition documents between PIMS and the accelerometer systems to document interfaces

4.5.5. Offline Processing of AOS/LOS Merged Data

Under normal circumstances, offline processing will occur using AOS/LOS merged data to insure that all data are included in the processing. Special circumstances may dictate that processing be performed on ‘all available’ data. PIMS will provide the capability to plot AOS data prior to the availability of all associated LOS data.

4.5.6. User's Guide for Accessing PIMS Acceleration Data Services

PIMS will develop a User's Guide to assist PI's in accessing the various acceleration data services. This User's Guide will explain acceleration data file formats and how to utilize data processing functions available through the PIMS WWW page.

4.6. Post-Increment 2 Requirements

The post-increment 2 requirements are scheduled enhancements to the PIMS software system. Based on the scope and identified requirements for initial operations, these are not included in the initial capabilities for PIMS ISS operations. Some of the items below are generic improvement statements while others deal with addressing a particular area of improvement.

4.6.1. New Display Formats

PIMS will develop new display and analysis techniques based on PI input. Such displays will be incorporated into the display systems for both the real-time and offline systems.

4.6.2. Distribution of Unprocessed Acceleration Data

PIMS will develop capabilities to route raw acceleration data packets directly to PIs.

4.6.3. Real-Time Processing of Acceleration Data Directly by PIs

PIMS will develop a real-time processing toolbox for direct use by the PIs. This toolbox will allow the processing and storage of acceleration data to the PI's local machine.

5. Increment Specific Requirements

TBD

6. References

[1] DeLombard, R., Hakimzadeh, R., Tschen, P., 1995, Experiment Support Requirements Document for Space Acceleration Measurement System-II, PIMS-001

[2] Microgravity Control Plan, International Space Station Program, September, 1998

[3] Rogers, M. J. B., Hrovat, K., McPherson, K., Moskowitz, M., Reckart, T., (1997) Accelerometer data Analysis and Presentation Techniques. NASA Technical Memorandum 113173